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The Effects of Instructional Methods and Individual Differences on the Cognitive Processing of Instruction

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for

Contracting Officer's Representative
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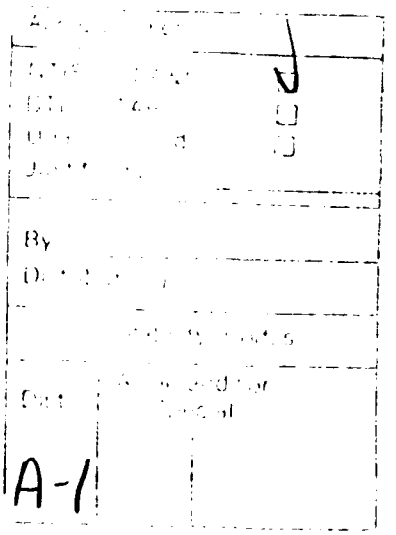

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This research examined achievement-treatment interaction (ATI) between individual differences and instructional methods on the cognitive processing (i.e., macroprocessing) of instruction. Individual differences in reading, prior knowledge, and anxiety were examined for three treatments (an adjunct postquestion with feedback group, a reading only adjunct postquestion group, and a reading only control group). The macroprocesses studied included previewing, reviewing, notetaking, and use of an alternate text.

Multivariate regression analysis of the posttest scores revealed main effect for treatment, prior knowledge, and anxiety. Regression analysis of the macroprocesses revealed main effect for treatment, a main effect for anxiety on use of alternate text, and anxiety and prior knowledge interaction for both use of alternate text and use of headings, and an anxiety, prior knowledge, and treatment interaction for use of alternate text. These results are discussed in the framework of prescriptive learning strategies.

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THE EFFECTS OF INSTRUCTIONAL METHODS AND INDIVIDUAL DIFFERENCES ON THE COGNITIVE PROCESSING OF INSTRUCTION

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THE EFFECTS OF INSTRUCTIONAL METHODS AND INDIVIDUAL DIFFERENCES ON THE COGNITIVE PROCESSING OF INSTRUCTION

INTRODUCTION

Research on the variables accounting for achievement from instruction has offered little encouragement or guidance to empirically oriented educational psychologists. Stephens (1967), for example, reviewed the results of a large number of studies comparing achievement from different instructional methods and concluded that "...in educational investigation one method turns out to be as good as another and that promising innovations produce about as much growth as the procedures they supplant, but no more" (p.10). A more recent review by Montague, Ellis, and Wulfeck (1981) cited similar concerns regarding how little guidance designers can take from a century of instructional research.

In the last few years instructional research has begun to focus on the interaction between individual differences and instructional treatments in an attempt to provide that guidance. This emerging area of research has come to be known as the study of aptitude-treatment interactions (ATI's). The logic propelling ATI research is straightforward: no one instructional method is presumed superior for all types of students. On the contrary, ATI research assumes that students with one set of characteristics, say higher ability or motivation, may be taught optimally using one instuctional method, whereas others with different characteristics may be taught more effectively another way. Unfortunately, ATI research has produced few replicable interactions (Cronbach and Snow, 1977; Snow 1976; Tobias, 1981). More puzzlingly, the number of significant interactions reported has been offset by an equal number of insignificant ATIs (Tobias, 1981a). And all the more disturbing are reports of significant interactions which cannot be replicated or when replicated produce significant interactions in the opposite direction (Peterson, 1977, 1979).

The purpose of the present research was to bring some order to the study of ATIs by examining some hitherto neglected variables. Rather than investigating differences in instructional methods, our research examined the types of cognitive processing students used while engaged in meaningful learning via microcomputer. Within this framework, then, the term macroprocesses refers to those relatively molar cognitive processes students use, such as reviewing, previewing, seeking clarification, or notetaking, when learning from instruction. The types of macroprocesses investigated included mental review, organizational strat-

egies, and obtaining assistance and clarification when confused.

For the most part, research in the area of adapting instruction to learner characteristics has ignored these macroprocesses. Not only do these macroprocesses need to be clearly defined and understood, but their relationship to variations in instructional methods and individual difference measures - and their interactions - require systematic examination.

The research design operationalized the macroprocessing construct by using microcomputers which not only presented instructional text, but provided the student with a number of text manipulating options while retaining data on the frequency of their use. For example, mental review was determined by the number and length of text reviews, by student notes taken on the computer, and by student reviews of these notes. The organizational strategies used were determined by examining the frequency with which students previewed the table of contents or previewed the text. Obtaining help and elaboration were indexed by the number of times the student used and reviewed an alternate, easier version of the text while working on the instructional material.

A secondary focus of this research was on the relationship between macroprocessing and anxiety. ATI research has attempted to demonstrate an interaction between anxiety and those instructional methods assumed to be differentially affected by anxiety. Recent reviews of ATI research, however, point to a need for investigations with stronger theoretical bases. Based firmly in a cognitive view of test anxiety, our research examined the relationship between anxiety and instruction by varying the level of instructional support provided to the learner (e.g., inserting adjunct postquestions, providing feedback, and allowing for preview and/or review of the instructional material).

It has been suggested that anxiety does not directly affect instructional outcomes, but, rather, affects the cognitive processes engaged by the instructional treatment, and these, in turn, affect performance (Tobias, 1980). From an information processing perspective, such a model assumes that anxiety interferes with the effective input of instructional material, in addition to affecting learning from instruction at other points (during both the processing and the output stages). It follows, then, that an instructional treatment which permits the learner to review effectively the instructional text will be selectively beneficial to highly anxious learners. A major purpose of this study was to test that hypothesis.

In general, prior research on anxiety and achievement suggests that highly anxious learners will engage in more frequent macroprocesses than low anxious students. This expectation derives from an information-processing model of anxiety (Tobias,1984) which hypothesized that the negative self-preoccupations typically associated with high anxiety absorb some portion of the individual's information processing capacity. Consequently, it follows, that only a reduced proportion of cognitive capacity remains available for processing task related information. It also follows that engaging macroprocesses such as review, and obtaining help or elaboration should be differentially beneficial for the achievement of highly anxious students when compared with their low anxious counterparts.

This study attempted to address the issue of whether anxiety interacts with the level of instructional support provided to the learner. Moreover, the "macroprocess" construct was incorporated into the design in an effort to detect the specific behaviors (e.g., previewing, reviewing, notetaking) employed by students varying in test anxiety, prior knowledge, and instructional support. The basic strategy, then, examined: (1) whether different instructional methods affected the frequency with which macroprocesses, such as those described above, were used by students; (2) the relationship between these macroprocesses and the individual difference measures of anxiety and prior knowledge; and (3) the interactions among them.

Review of Research

There are a number of converging lines of evidence supporting the general hypotheses outlined above. These include research on the interaction between prior achievement and instructional methods and research on the use of questions inserted in text, and on student strategies such as reviewing the instructional text. Each of these areas of research is discussed briefly in an effort to establish the theoretical perspective guiding this study.

ATI Research

Most ATI researchers seek interactions between instructional methods and cognitive aptitudes such as intelligence or verbal ability. Tobias (1977a) suggested that examining the interaction between prior achievement, rather than aptitude, and instructional method may be more relevant to instructional research for a number of reasons. First, correlations between aptitudes and achievement from instruction

vary dramatically over time, a finding most recently demonstrated by Federico (1983) and by Burns (1980). ATIs found at the beginning of an instructional program, then, may be irrelevant once the instructional sequence is underway. Second, it may be difficult to construct alternative methods of instruction by relying only on aptitude differences. Third, the specific psychological processes engaged by a particular content area can be sampled using an achievement oriented pretest, whereas more general aptitude measures may not provide such potentially useful information.

These concerns, among others, led to the hypothesis that the level of prior achievement is inversely related to the amount of instructional support required to facilitate achievement. That is, students with low levels of prior achievement in a particular content area are expected to require substantial instructional support to accomplish objectives. Conversely, those higher in prior achievement are expected to need little instructional support. Operationally, prior achievement is readily defined by students' pretest scores. Instructional support can be defined as the assistance provided to the learner in terms of organizing the instructional content, eliciting responses, providing feedback regarding those responses and so on.

There is considerable research support for this hypothesis (Tobias, 1977a; 1981; 1982). For example, it has been demonstrated that students with limited prior achievement learned most under conditions of maximal instructional support, whereas this effect was less marked for students with higher levels of prior achievement. A more detailed review of this literature can be found elsewhere (see Tobias, 1977a; 1981).

It should be noted, though, that support for the prior achievement-instructional support hypothesis has been accompanied by some conflicting evidence (Tobias, 1982) suggesting that other, more subtle variables may be involved. This disparate evidence suggests that external differences between instructional methods may be less important than the way students process the instructional material. These findings led to a reformulation of the achievement-treatment interaction hypothesis.

It was reasoned that for novel content all forms of instructional support would probably enhance students' active attempts to comprehend and organize the subject matter. For such content, providing support should enable students to process the content more deeply than they otherwise could. In such situations instructional support, such as providing objectives, advance organizers, or similar techniques may improve the ability of students to organize the material. Other support, such as eliciting overt responses, providing

feedback, and using adjunct questions may facilitate achievement by making it easier for students to fix their attention on complex, novel content.

On the other hand, on familiar material high levels of instructional support may be unnecessary for a variety of reasons. It is assumed that familiarity reduces the difficulty of the material to be learned, despite its intrinsic complexity. Support to improve the organization of easy material may then be unnecesary, since students' knowledge of the subject matter may impose an organizational structure. Similarly, the high degree of attention required for novel material is unnecessary when students' have had considerable prior experience with similar or related content areas. For these reasons instructional support is not expected to improve achievement for students with high levels of prior knowledge. Such an analysis suggests that external differences in instructional methods are significant only to the degree that they influence the macroprocesses used by students while engaged in instruction. Research examining the interaction between the level of instructional support and use of macroprocesses may shed light on this issue.

Adjunct Questions Research

In general, the adjunct question paradigm consists of interspersing questions in a passage of text contiguous to the material on which they are based. In a typical study one or two adjunct questions are inserted either before (prequestions) or after (postquestions) a segment of text - usually one or two pages of text. Adjunct questions and the related text segments are presented separately, and the reader is usually not permitted to review the text once it has been presented. Upon completion of the entire passage, a posttest is administered to determine the amount of questioned (relevant) and non-questioned (incidental) material retained by the readers.

For the most part, studies of this sort have reported consistently that the prequestion group retains about the same amount of material directly questioned (relevant) as the postquestion group (Rickards, 1979), and that both adjunct question groups retain more of the questioned material than a reading only control group (Anderson and Biddle, 1975). This has been called the "direct instructive effect" (Rothkopf, 1966) or the "direct effect" (Anderson & Biddle, 1975). More important, however, these studies have demonstrated consistently that a postquestion group recalls more of the text material not actually questioned (an indirect effect) when compared with a prequestion group or a reading only control group.

As Rickards (1979) noted in his review of the adjunct postquestions literature, the paradigm shift to a more cognitive view of learning is evidenced in the number of studies that have used adjunct postquestions to assess the "depth of processing" or conceptual level necessary to respond correctly (Duell, 1974; Rickards, 1979; and Rickards and DiVesta, 1974). Initially proposed as a framework for understanding human memory (see Craik & Lockhart, 1972), the depth of processing methaphor has come to represent a useful way of analyzing reading comprehension. Within this framework, the "deeper" (i.e., more semantic) the processing, the better the comprehension.

Despite the relative abundance of studies using adjunct postquestions, few investigations have been directed at the effects of individual differences on the effectiveness of adjunct postquestions inserted in text. These individual difference - adjunct qustion studies have, for the most part, employed the ATI paradigm. For example, Frase, Patrick & Schumer (1970) studied the effectiveness of pre- and postquestions on students varying in level of motivation. Under low incentive conditions, presenting adjunct questions after the text enhanced recall. As the incentive increased, the effectiveness of the postquestions decreased. Apparently the adjunct postquestions served to increase a student's "forward and backward" processing of the text even if the individual's motivation was low.

Rothkopf (1972) reported that low ability students (i.e., those with ineffective reading skills) achieved more under the adjunct questions conditions when compared to the no adjunct question group, as expected from the achievement - treatment hypothesis (Tobias, 1977b). The lower ability students, Rothkopf argued, were aided in terms of increased inspection rates (attention to text) produced by the insertion of adjunct postquestions.

Hiller (1974) varied two sets of inserted postquestions designed to have different levels of readability. Individual differences in verbal ability, anxiety and self-confidence were also examined as they interacted with four treatment levels: (1) relatively easy inserted post- questions; (2) relatively difficult inserted postquestions; (3) passive reading; and (4) idiosyncratic study. The scores on the immediate retention test for the difficult postquestion group reading the difficult lesson were correlated positively with self-confidence and negatively with test anxiety. Thus, learning was correlated with anxiety and self-confidence for the two treatments in which the text had lower than average readability, but not in the average readability level treatment.

Shavelson, Berliner, Ravitch, and Loeding (1974) attempted to extend the study of the interactions between individual differences in aptitudes and instructional treatments by manipulating the position and type of questions inserted in prose material. Five aptitude measures were administered: (1) vocabulary; (2) hidden figures test for general ability; (3) letterspan or recall for letters; (4) Taylor Manifest Anxiety (Taylor, 1953); and (5) memory for semantic implications. Total and incidental learning scores were regressed on the aptitude measures to test for ATI's. No interactions between memory ability, measured by the letterspan and semantic implications tests, and treatments were found. Moreover, anxiety and the hidden figures test also did not interact with the treatments. The vocabulary score did interact with the treatments on both the immediate and the delayed retention test indicating that higher order adjunct questions placed after the text facilitated the performance of subjects with low vocabulary scores.

The studies presented above have varied with respect to the individual difference dimensions investigated. Despite these variations, one salient point has emerged: the more support the adjunct question treatment provides to the learner, the greater the achievement. When students are asked questions that are directly relevant to the material to be learned, their achievement increases. When adjunct post-questions lead to increased attention, that treatment, in turn, produces increased learning.

Student Review Strategies

The majority of studies using adjunct questions have included instructions to the subjects not to review the text. However, Gustafson and Toole (1970) permitted review and allowed their subjects to study a passage for as much time as they wished. Their results were, in general, consistent with the basic findings of a mathemagenic effect reported by Rothkopf (1967, 1972). The ability to attend selectively to, and presumably review, the questioned material produced a substantial improvement in intentional learning and a small improvement in incidential learning for the adjunct question group. Unfortunately, this investigation did not report the frequency of review by students. Thus, conclusions drawn about the precise role of review as a learning strategy in this study are tenuous.

Garner and Reis (1981) investigated reading "lookbacks", i.e., reviewing previously read material, among good and poor readers in grades 4 thru 10. Reviewing was explicitly encouraged, and the investigators monitored the lookback behaviors. Their results indicated that only the older good

readers used the reviewing strategy with any frequency or degree of success.

In a further study, Alexander, Hare, and Garner (1984) investigated review strategies among older (undergraduates), proficient readers. Prior to instruction subjects were asked what strategies they would use on a task that required reading a passage and answering subsequent questions. After the instructional task, subjects were then asked what strategies they actually used. It was reported that those who said they used a particular strategy (e.g., underlining or reviewing), actually did so and, conversely, very few subjects used a strategy that they had not previously reported. However, the rather surprising result of this study was that more than half (29 out of 52) of these older, proficient readers failed to review the text at all. The authors noted that this may be an artifact of their design, since many students reported that they thought they were not permitted to look-back or review the material.

In general, the literature on reading comprehension suggests that there are both quantitative and qualitative differences in both metacognitive and reading comprehension skills and strategies between good and poor, as well as older and younger, readers. However, there is some evidence that even experienced, good readers do not routinely use certain strategies thought to be in their repertoire (Alexander, Hare, & Garner, 1984). Clearly, more research is needed in this area, most especially in the area of strategy training both with different age groups and differing skill levels.

Anxiety Research

Recent reviews of ATI research dealing with anxiety (Tobias, 1977a, 1980) suggest that anxiety does not directly affect instructional outcomes. Instead, anxiety affects the cognitive processes engaged by the instructional material and methods, and these, in turn, affect performance. More specifically, this information - processing model of anxiety assumes that test anxiety interferes with the effective input of the instructional material, in addition to affecting learning from instruction at other points (i.e., during both processing and output stages). It follows, then, that an instructional method which permits the learner to review instructional input effectively will be selectively beneficial to highly anxious students. This research tested this hypothesis as well.

Summary

ATI research relating prior achievement and instructional support has, in general, supported the hypothesis of an inverse relationship between these variables. That is, generally, students with little relevant prior experience typically profited most from instructional methods offering substantial instructional support, whereas such support was often of little benefit to students with high levels of relevant prior experience. Conflicting findings in this area, and in ATI research in general, have led to an emphasis on the cognitive processes engaged by instructional methods and by student characteristics. A tacit assumption of that approach is that the psychological processes engaged by instructional methods may lead to more consistent results than the more superficial characteristics of instructional methods.

Research has also indicated that adjunct questions are an important source of instructional support in that they typically improve the achievement of students on material relevant to the content of the questions. While there has been a good deal of speculation about the mechanisms by which adjunct questions achieve their effect, little direct evidence regarding these questions is available.

The aim of the present study was to determine whether different instructional methods, such as providing text augmented with adjunct questions, or questions with feedback, induced students to use different macroprocesses while reading. Further, we investigated whether students of different characteristics, i.e. varying levels of prior achievement, reading ability and anxiety used different instructional methods. Finally, we studied whether these two variables interacted.

METHOD

Students were randomly assigned to read an instructional text displayed by microcomputer in one of three different methods. In each condition students could use a variety of options to facilitate study of the text. Individual difference data, including measures of reading ability, prior knowledge of the content, and anxiety were administered to students.

Subjects

Volunteers for this experiment were recruited from the student population of the City College of New York. A total of 120 S's participated in the study. The sample was comprised of 68 males and 52 females with a mean age of 21. Students were paid $12 for their participation.

Pilot Study

In a preliminary study 47 students were asked to "list all of the study techniques you use in learning from textbooks, articles and the like." Student responses were submitted to content analysis and the single most prominent strategy appeared to be reviewing, followed by underlining, preparing summaries taking notes, skimming, obtaining extra help by use of dictionary, and consulting title headings. The equipment available, Apple II microcomputers, prevented implementation of the underlining strategy, though as many of the others as possible were used in this investigation.

Procedures

The instructional materials were presented using Apple II Plus microcomputers. The time subjects spent reading each text segment, along with their responses to all questions, were recorded automatically by the computer. In addition, the computer recorded each use of the macroprocessing options to be described below.

Subjects were randomly assigned to one of three instructional treatments: (1) a reading only control group; (2) an adjunct postquestions group; and (3) an adjunct postquestions with feedback group. Postquestions required a constructed response and were presented after each screenful of text, i.e., two or three paragraphs. Subjects' responses were evaluted by the computer and three classes of feedback were provided: (1) subjects were informed that their response was identical to the answer provided in the text; (2) the response was similar to, or equivalent to one provided in the text; and (3) the response appeared to be incorrect and the correct response was provided.

The procedures were administered in two sessions. In the first session subjects were given a pretest covering the instructional material to be presented subsequently (Cronbach's Alpha Reliability = .75), the Nelson Denny Reading Test (Brown, et al., 1981), the Test Anxiety Scale (Sarason, 1972), four subtests of the Learning Study Skills Invetory (Weinstein, 1982), and the Worry-Emotionality Scale (Morris et al., 1981) with instructions to complete it in terms of the way they felt at that moment. These materials were administered in group settings ranging from three to 35 subjects.

In the second session students were assigned to microcomputers to study the text. When students completed one half the instructional material the Worry-Emotionality Scale (Morris et al., 1981) was administered on the computer with instructions to respond they way they felt while studying the material. Upon completion of the instructional material, each subject completed a paper and pencil version of a constructed response posttest (Cronbach's Alpha Reliability = .92) and another version of the Worry-Emotionality Scale with instructions to report how they felt while working on the posttest.

Instructional Text

The instructional material consisted of 22 screenfuls of text, 173 sentences making up roughly forty-nine paragraphs. The text presented some major concepts of data processing, computer programming, and a sample of illustrative commands of the BASIC programming language. Each of the 173 sentences in the text was numbered and exposed one at a time. When a sentence was read and the space bar depressed, it was erased though the space it occupied and its number remained.

The text was estimated to require a 14th grade reading level (Fry, 1969). An alternate, easier version of the text was constructed which had the same content in every para-

graph as the main text, but used an easier vocabulary, i.e., the 10th grade according to the Fry (1969) formula. The alternate text also was structured so that superordinate concepts and sentences preceded subordinate ones to a greater extent than in the main text.

All students could choose any of these options while reading the text: they could (1) review, or (2) preview any sentence, or group of sentences; (3) consult the alternate version of the text after completing a paragraph. 4) The alternate text could be reviewed, or (5) previewed. 6) Students were able to take notes on the computer system, (7) and review their notes. 8) An organizational display could be requested containing all the headings in the main and alternate texts, the sentence numbers covered by each heading, and the number of the sentence students were presently reading. 9) A menu of the options available, and how they could be invoked could also be requested.

The options described above could be invoked by students at any time during the course of the presentation with two exceptions: (1) the adjunct question group could invoke the options only after they had responded to the question; and (2) the alternate version of the text could be requested only after a complete paragraph had been read. A beep was sounded by the computer at the end of a paragraph signaling that the alternate version of the text could be consulted.

Prior to the beginning of the instructional presentation, a description of each of the options was provided. The description required students to use each option at least once to ensure familiarity with the procedures prior to instruction. After the first few introductory remarks, the descriptive material followed the same structure as the ensuing instructional material, i.e., each sentence was numbered and presented one at a time and the space bar on the computer's keyboard had to be depressed to produce the next sentence.

RESULTS

Table 1 displays the means and standard deviations for the major independent and dependent variables in this study, as well as descriptive data on the sample.

Insert Table 1 here

The means and standard deviations for the macroprocessing options, and the percentage of students not employing any of the options are displayed in Table 2.

Insert Table 2 here

The standard deviations for the macroprocessing data indicate a great deal of variability. In order to reduce the effects of outliers the data for students whose use of any of these options fell over three standard deviations above the mean we set at the third standard deviation value. Despite that, it is evident that the variability was still very large. The posttest was divided into two sections: those items related to any of the adjunct postquestions (i.e., relevant items), and those unrelated, or incidental to the adjunct postquestions. Table 2 also displays the correlations of each of the options with the incidental, relevant, and total posttest score.

Multivariate regression analysis results of the posttest are displayed in Table 3.

Insert Table 3 here

As expected, pretest contributed significantly to posttest scores on both the relevant and incidental items. Also as expected, there were significant differences among groups in achievement on both the relevant and incidental portions of the posttest. Both groups receiving adjunct postquestions outperformed the reading only control group on the posttest. There was also a main effect attributable to worry, a component of test anxiety (Morris, et al., 1981), on the incidental portion of the posttest, indicating that anxious stu-

Table 1. Mean and Standard Deviations for Various Variables in Macroprocessing Study, by Group.

Variables	Adjunct Questions plus Feedback	Adjunct Questions	Read Only
Posttest Incidental	13.14 5.40	14.84 5.86	11.99 5.05
Posttest Relevant	17.56 5.28	17.90 6.00	13.91 5.16
Posttest Total	30.70 10.13	32.74 11.48	25.89 9.47
Pretest Incidental	8.34 3.74	8.51 2.87	7.74 3.03
Pretest Relevant	11.10 4.43	12.26 3.82	11.37 3.38
Pretest Total	19.45 7.41	20.77 5.77	19.12 5.45
<u>Anxiety Variables</u>			
Test Anxiety	17.00 6.46	17.97 8.28	19.44 6.35
Worry-Pretest	8.16 3.67	8.62 4.28	8.67 3.84
Emotionality-Pretest	7.39 3.85	8.05 4.66	6.67 2.33
Worry-Program	9.24 3.91	9.62 4.66	9.33 4.04

Table 1 continued.

	Adjunct Questions plus Feedback	Adjunct Questions	Read Only
Anxiety Variables Continued			
Emotionality-Program	7.53 3.68	7.03 2.58	8.05 3.56
Worry-Posttest	8.59 3.36	9.76 4.61	11.86 5.57
Emotionality-Posttest	7.22 3.54	7.50 3.87	7.79 3.56
Nelson-Denny Reading Raw Scores			
Vocabulary	41.18 21.13	42.51 23.75	38.23 22.27
Comprehension	29.60 14.69	30.74 18.32	27.28 16.27
Total	71.58 31.48	72.18 18.32	65.44 36.65
Study Skills			
Motivation	28.08 7.29	31.13 8.89	30.77 8.75
Self-Testing	17.22 4.20	16.53 3.60	16.33 3.18
Self-Scheduling	17.14 3.64	14.40 4.42	15.13 4.63
Attitude	7.06 3.01	7.34 3.00	6.85 2.73
Information Processing	64.30 10.68	55.11 10.08	58.18 13.16

Table 2. Means and Standard Deviations of Option Use, Percentage Not Using Each Option, and Correlations with Posttests

		Adjunct Questions plus Feedback	Adjunct Questions	Read Only
Macroprocessing Frequency Data				
Preview Incidental[1]	M	.55	1.02	1.13
	SD	1.70	2.22	2.11
	r =	-.22	.14	.05
Preview Relevant[2]	M	.50	.72	.49
	SD	1.16	1.56	1.10
	r =	-.30*	.10	.03
Preview Total[3]	M	1.05	1.74	1.63
	SD	2.51	3.54	3.04
	r =	-.35*	.14	.06
	% not using	69	59	58
Review Incidental[1]	M	5.77	9.53	6.19
	SD	12.17	12.83	11.01
	r =	-.05	.37*	.39**
Review Relevant[2]	M	3.78	6.70	3.74
	SD	8.18	9.82	7.44
	r =	-.02	.36*	.33*
Review Total[3]	M	9.55	16.23	9.93
	SD	20.06	22.24	18.19
	r =	-.03	.37*	.40**
	% not using	54	42	49
Alternate Text Incidental[1]	M	2.53	23.14	9.95
	SD	7.06	29.06	17.46
	r =	-.23	.15	.16

Table 2, part 2

Alternate Text Relevant[2]	M	2.21	14.35	5.44
	SD	6.14	18.60	10.55
	$\underline{r}$ =	-.20	.10	.09
Alternate Text Total[3]	M.	4.74	37.50	15.40
	SD	13.04	47.32	27.48
	$\underline{r}$ =	-.21	.14	.14
	% not using	69	52	41
Review-Alternate Incidental[1]	M	1.84	2.23	2.14
	SD	8.78	4.95	6.21
	$\underline{r}$ =	. 26	.13	-.23
Review-Alternate Relevant[2]	M	.42	2.06	1.32
	SD	1.62	5.29	3.64
	$\underline{r}$ =	.22	.11	-.24
Review-Alternate Total[3]	M	2.28	4.29	3.46
	SD	10.36	9.94	9.75
	$\underline{r}$ =	.24	.14	-.27
	% not using	88	88	71
Notes From Incidental[1]	M	2.92	3.79	6.19
	SD	4.72	5.28	7.27
	$\underline{r}$ =	.26	.22	.19
Notes From Relevant[2]	M	.87	1.74	2.92
	SD	1.56	2.64	4.22
	$\underline{r}$ =	.43**	.18	.10
Notes Total[3]	M	3.79	5.54	9.10
	SD	5.98	7.67	10.97
	$\underline{r}$ =	.33*	.21	.20
	% not using	47	32	18
Review-Notes from Incidental[1]	M	.21	.48	.62
	SD	.70	.84	1.24
	$\underline{r}$ =	.27	.16	.25

Table 2, part 3

Review-Notes from Relevant[2]	M	.08	.20	.30
	SD	.36	.52	.58
	r =	.25	.23	.11
Review-Notes Total[3]	M	.29	.69	.92
	SD	.96	1.09	1.64
	r =	.30	.22	.28
	% not using	86	67	74
Headings from Incidental[1]	M	.39	.64	.91
	SD	.86	1.21	1.28
	r =	-.14	.31	-.07
Headings from Relevant[2]	M	.18	.27	.48
	SD	.56	.57	.78
	r =	-.18	-.20	-.16
Headings Total[3]	M	.58	.92	1.38
	SD	1.11	1.53	1.93
	r =	-.11	.13	-.11
	% not using	72	70	57

1=Correlated with Incidental Posttest
2=Correlated with Relevant Posttest
3=Correlated with Total Posttest

* = $p. < .05$
** = $p. < .01$

TABLE 3. Results of Multivariate Regression Analysis of Posttest Scores

N=112	WILKS[1]	UNIVARIATE F's	
		PostRel	PostInc
Treatment	5.12**	8.12**	3.36°
Pretest	15.83**	29.95**	25.51**
Worry Scale	2.03	2.28	4.09°
Trt * Pretest	<1	<1	<1
Trt * Worry	<1	<1	<1
Pre * Worry	<1	<1	<1
Trt*Pre*Worry	<1	<1	<1

1. Approximate transformation to the F distribution.
** signif LE .001 * signif LE .01 °signif LE .05

dents learned less than those lower in anxiety. Further, multivariate regression analysis uncovered no interactions among these variables.

Multivariate regression analysis results of the macroprocessing option data are displayed in Table 4.

Insert Table 4 here

This analysis indicated a difference among the three groups for the frequency of overall option use, with significant univariate effects for use of the alternate text and notetaking, in particular. In general, the group receiving adjunct postquestions and feedback used the macroprocessing options least frequently, while the adjunct postquestions only group used the options most. A main effect for worry was found for the alternate text option indicating that the more anxious students tended to use the alternate, easier version of the text more frequently than less anxious students.

Moreover, this analysis of the macroprocessing data produced a number of significant interactions. For example, a significant pretest by worry interaction was found for use of both the alternate text and headings options.

It should be noted, here, that deviation scores for both anxiety and prescore were computed and used in the regression analyses and are represented by the x axis in the figures. The use of deviation scores has been recommended to reduce the effects of multicollinearity among predictor variables (Cronbach and Snow, 1977).

In addition, a significant triple interaction of treatment by pretest by worry was found for the alternate text option. This interaction is depicted in Figure 3.

Insert Figure 1 here

Interestingly, the shape of the interaction between prescore and anxiety is essentially the same for both the feedback and the control groups, while the postquestions only group had a more or less parallel slope for the anxiety regression line but a steeper slope for the prescore regression line.

TABLE 4. Results of Multivariate Regression Analysis of Macroprocessing Options

N=120	WILKS[1]	UNIVARIATE F's						
		Rev	EZ	RvEZ	Notes	RvNotes	Hdgs	Prev
Treatment	2.88**	1.4	11.54**	<1	4.06°	2.42	2.87	<1
Pretest	<1	<1	1.46	<1	1.62	3.12	2.5	<1
Worry Scale	1.8	2.73	3.67°	2.90	<1	<1	2.76	1.95
Trt * Pretest	1.3	2.0	<1	2.49	<1	<1	2.08	2.11
Trt * Worry	<1	<1	<1	<1	<1	<1	<1	<1
Pre * Worry	2.04°	<1	10.78**	<1	1.10	<1	4.06°	1.87
Trt*Pre*Worry	1.33	2.56	4.47°	<1	2.39	<1	2.86	1.77

1. Approximate transformation to the F distribution.
** signif LE .001 * signif LE .01 ° signif LE .05

T1 - Adjunct postquestions & feedback
T2 - Adjunct postquestions
C - Reading only control

Prescore ---------
Anxiety ————————

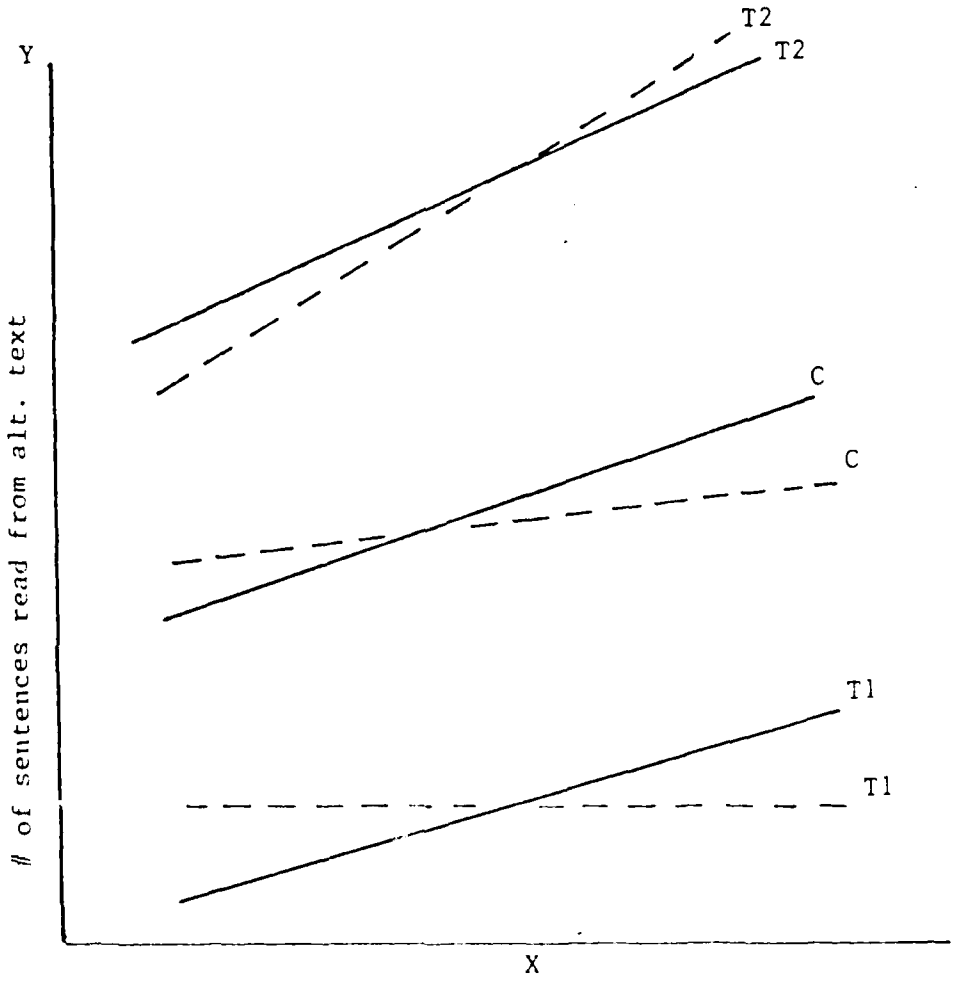

Figure 1. Interaction of Pretest Score, Anxiety and Instructional Method on the use of Alternate Text

The interaction between anxiety and prescore for both the feedback and control group is quite similar, while for the postquestions only group the influence of prescore was much stronger.

DISCUSSION

The significant differences on both the relevant and incidental items of the posttest confirm prior findings that adjunct postquestions facilitate achievement on material which is both incidental and relevant to the content of the question. In this study the two groups receiving questions outperformed the reading-only control group both on relevant and incidental items of the posttest. Of some interest was the fact that the adjunct question group had slightly, though not significantly, higher scores than the group receiving feedback. Perhaps the presence of feedback led this group to process the text less thoroughly than the adjunct postquestion only group.

The most surprising aspect of the macroprocessing data was the incredible variability with which the macroprocessing options were employed. The percentage of students who did not use an option at all varied from 18% to 88%. Despite this low mean frequency of usage, a number of students used these options very often indeed. The standard deviations of the frequency data are often two and three times higher than the mean! Clearly, there was incredible variability in the frequency with which options were used.

There was a significant difference among the groups in terms of the frequency with which options were used. In general, the group receiving feedback used the options least often, and the adjunct question group most frequently. These results appear to suggest that the group receiving feedback may have little need to use the options due to the information provided by the feedback. That is, it may have been unnecessary for these students to use the review option, for example, in order to determine the correct answer, since it was supplied to them. The large mean differences on use of review supports this thinking. Presumably, these students were similarly less motivated to employ the other options provided. This aspect of the results confirms Tobias' (1982) expectation that it is instructionally unsound to do for students what they could do for themselves, i.e. supply their own confirmation as to whether answers are correct or not. Apparently, by providing feedback these students were less active in their reading of the text, at least as determined by the frequency of macroprocessing use.

Interactions

The interaction between prescore and anxiety on the number of alternate text sentences read indicates that the more anxious students tended to read more alternate sentences than those lower in anxiety. This finding can be expected from a formulation (Tobias, 1984) suggesting that anxiety absorbs some portion of cognitive capacity, leaving less capacity for task solution. Use of the alternate, easier text may well have been less demanding of cognitive capacity for these subjects, hence, as anxiety increased they attempted to reduce the cognitive demand the main text passage called for by consulting the less demanding alternate passage. The number of alternate sentences consulted had an essentially flat relationship with prescore, indicating little variability attributable to the amount of prior knowledge. A similar interaction was found for frequency with which the headings were used, though the magnitude of this interaction was substantially smaller than that involving the alternate text.

A triple interaction was also found for the number of alternate text sentences read by students. This interaction involved anxiety, prescore, and instructional method. In general, the number of sentences read were unrelated to prescore for the control and feedback groups. For the adjunct postquestion group, however, as prescore increased the tendency to use the alternate text also increased. Presumably, students in this group were uncertain regarding the correctness of their answers to the adjunct postquestions and, hence, felt some need to consult the alternate, easier text. Surprisingly, the more knowledgeable the student about the subject matter, as reflected in the prescore, the more likely they were to consult the alternate text. The interaction involving anxiety had a similar slope for all three instructional groups, i.e., as anxiety increased there was a tendency for the number of alternate text sentences read to increase as well. The rationale for this finding has been described above.

Option Use

A surprising finding was the fact that, in general, students use of macroprocessing options had only limited relationships to their postest scores, see Table 2 for correlations , and similarly limited relationships to reading ability. It was assumed that students would invoke some or all of the options to help them learn the material more efficiently, and that use of these options would be positively related to outcomes. Instead, the findings suggest that option use frequently was not in the service of increasing comprehension.

There are two possible interpretations of these data. The first of these is that students may not have been particularly motivated to do well on this task. This interpretation would suggest that students used the options out of curiousity regarding how they worked, rather than to improve their learning. The mean achievement scores tend to contradict this interpretation. The total possible number of points on the posttest was 46. The percentage correct for the two postquestions groups was approximately 70%, a reasonably high score on a difficult test. It is conceivable that a highly motivated group may have done much better, though these data do not suggest an absence of motivation as a major interpretation of these results.

The alternative interpretation has to do with the fact that students may not know which instructional strategies are especially effective for improving their performance. The high variability of option use, and the low relationship with posttest scores and reading ability tend to support this interpretation. Students are rarely instructed, at any educational level, regarding how to improve their learning and studying. While students indicated frequent use of review in the pilot study, the data for number of sentences reviewed tell a different story. The feedback and control groups reviewed approximately 5% of the sentences, and the adjunct postquestions group reviewed about 9%. This was not a high percentage of reviews, in view of the fact that the mean posttest score indicated a good deal of room for improvement.

Prescriptive Use of Macroprocesses

An interesting question arising in this context is what would be an ideal use of options? That is, how frequently should good or poor readers use these options? The present data do not answer this question satisfactorily, since the median correlation between the total frequency of option use and total posttest score was only -.03 for the feedback group, and .14 for both the adjunct question and reading-only group. Clearly, such correlations do not warrant recommendations regarding ideal use of instructional options.

The study does, however, offer an interesting model in order to determine what could be ideal use of options. Though there was variation among the treatment groups, in this investigation the frequency of options used correlated positively with the total posttest score. Analyses of these correlations may be useful in building a model of ideal option use. That is, if option use is highly correlated with achievement, then such use should be recommended. Furthermore, the presence of data regarding students' prior

achievement, reading ability, and anxiety permits the computation of partial correlation coefficients in which the contributions of these variables can be studied in further research. It follows, then, that the use of correlational analyses is potentially powerful for making recommendations regarding ideal option use.

In future research it may be useful to assist students with option selection. It would appear that students should review the preceding text in those instances when their answers to an adjunct question are wrong. In that way they may be able to correct their misconceptions prior to moving on to succeeding text. A future study, for example, might examine the effect on the learning outcomes of some students, say those with low pretest scores, of prescribing use of the review option. If use of review in these situations does, in fact, raise achievement, one can then envision a succeeding study in which students are taught this general strategy while their performance is monitored on tasks similar to those used in this experiment.

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